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Improved Electromechanical Master-Slave Manipulator

The problem:

To devise an improved master-slave manipulator for use in radioactive materials laboratories, capable of operating with mobility and flexibility from a distant location. The new system should provide greater reliability, increased ease of repair, higher force boost ratios, lower backlash and effective inertia, and a better geometric configuration than that of presently available manipulators.

The solution:

A new electric master-slave manipulator which uses force multiplication and allows the operator at the master arm to feel either all or some fraction of the force at the slave arm. The master and slave sections are connected only by an electric cable so that the slave section can be mounted on a mobile support and operated throughout a very large volume. Both the master and slave arms are able to execute seven distinct motions: x, y, z, elevation, azimuth, twist, and tong squeeze.

How it's done:

The new electric master-slave system incorporates a number of improvements over conventional electrical and/or mechanical manipulators. Each of the seven independent motions of the manipulator is driven by a specially designed force-reflecting servo having a one-to-one correspondence between the motion at the master and the motion at the slave. These motions are bilateral: i.e., forces and motions applied at the master arm are transmitted to the slave via electric cable, and conversely, forces and motions at the slave are transmitted to the master. This enables the operator at the master arm to "feel" the load at the slave arm even though there is no direct mechan-

ical link between the sections. Force multiplication through the servos between the master and slave allows the operator the choice of "feeling" either the entire load, one-half, or one-fifth of it. The slave arm has a 50-pound load capacity in any direction.

In addition, the manipulator has completely solid state amplifiers, and low backlash and friction.

Notes:

1. Viewing is the primary factor which limits the maximum operating distance between the master and slave arms of manipulators. Numerous trial methods have indicated that "head controlled" TV has definite advantages including: magnification of the viewing area, operation over great distances, elimination of an optical path between the master and slave section, and capability for viewing at more varied angles.
2. Additional details are contained in *Proceedings of 14th Conference on Remote Systems Technology*, 1966, p. 115-123.
3. Inquiries concerning this innovation may be directed to:

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(continued overleaf)

Patent status:

Inquiries about obtaining rights for commercial use of this innovation may be made to:

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U.S. Atomic Energy Commission
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